pulse, spurwood

PATENT SPECIFICATION

(11) 1 570 507

1 570 507

(21) Application No. 51303/76 (22) Filed 8 Dec. 1976
(31) Convention Application No. 2 557 020 (32) Filed 18 Dec. 1975 in
(33) Fed. Rep. of Germany (DE)
(44) Complete Specification published 2 July 1980
(51) INT. CL.^{3} A61N 5/06
(52) Index at acceptance
F4R 320 328 402 40Y FJ

(19) THE PATENT OFFICE LONDON

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(54) DENTAL TREATMENT DEVICE FOR HARDENING PHOTO-POLYMERIZABLE DENTAL TREATMENT SUBSTANCES

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(71) We, ORIGINAL HANAU QUARZLAMPEN GMBH, a body corporate organized under the laws of the German Federal Republic, of Höhensonne-Straβe, D-6450 Hanau (Main), German Federal Republic, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a dental treatment device for hardening photo-polymerizable dental treatment substances.

Various hardenable substances have been proposed for use in dental sealings, fillings and dentures but those substances which have been conventionally used suffer from the disadvantage that the dentist has to mix them and treat the tooth therewith rather quickly since hardening takes place almost immediately. Thus a defective filling can seldom be corrected.

More recently, photopolymerizable substances have been proposed for the same use and these substances have the advantage that the dentist has sufficient time within which carefully to prepare the tooth as hardening takes place only under the effect of ultraviolet radiation.

Ultraviolet radiation devices have been proposed for dental treatment using fibre-optic conductors for transmitting a desired ultraviolet radiation to a tooth.

In order to produce the ultraviolet rays, a discharge lamp is used which is arranged in a casing in front of a reflector, the operating principle of the lamp corresponding to that of a standard medical radiation apparatus, having a warming up phase of approximately 3 to 5 minutes. In order that the radiation produced during this period of time does not reach the point of treatment via the light conductor, filters, absorbing the ultraviolet radiation can be placed in the path of the rays at the end of the light conductor facing the source of radiation.

A radiation apparatus has also been proposed which is shaped as a hand lamp with a curved light-conducting member and having a casing shaped like a pistol. During ultraviolet radiation treatment, the apparatus must be held in the hand and manually directed in order to apply the rays onto the surfaces to be treated.

Due to visibility and size, handling of such an apparatus is difficult so that there is the risk of portions being irradiated which should not be exposed to any ultraviolet radiation, which might result in burning of tissue in the mouth of the patient.

A radiation apparatus has also been proposed in which the transmission of electromagnetic waves is effected by a liquid light conductor having absorption means, in order that only radiation of desired wave lengths can appear at the point of treatment. A high-pressure lamp is used as an ultraviolet ray source and in order to avoid time delays when starting, the lamp is switched over from basic load operations to a so-called pulse operation when hardening photo-polymerizable dental layers, whereby the lamp is over-loaded for short times. Because of the continuous power input of the lamp on basic load, this operating method results in an undesired development of heat. At the same time, by this mode of operation the life of the lamps is shortened.

According to the present invention there is provided dental treatment apparatus for hardening photo-polymerizable dental treatment substances, wherein the apparatus comprises an ultraviolet ray source and a light conductor for transmitting radiation from the source to the place of treatment, and wherein means are provided for operating the source of ultraviolet rays so as to cause it to emit the dose of radiation required for hardening said substances from the time of switching-on for a period of 10

to 30 seconds, and said means and the source being so arranged that at the end of the radiation time the input per centimetre of arc length of the ray source will be at least four times more than that of standard operation (as hereinafter defined).

With the present apparatus, dental filling substances may readily be hardened, with the lamp being in operation only during the time of treatment. Nevertheless radiation times like those attained by the above mentioned pulse method may be used, so that the lamp of the present apparatus, as compared to the previously proposed apparatus, has a longer life and an excessive heat development is prevented.

Preferably the radiation time will be 20 seconds and the power input per centimetre of arc length of the ray source at the end of the radiation time is five times to seven times as much as that of standard operation.

When using the present radiation apparatus, it unexpectedly appeared that, in addition to the expected advantages, a better hardening of the photo-polymerizable dental filling substance took place as compared with the treatments using the aforesaid pulse method. Possibly the reason for this is that with the pulse method, the outer irradiated layer is hardened immediately by the higher radiation at the beginning, and thus acts as an absorber for the subsequently applied radiation. In contradistinction thereto the radiation power which rises from low to high values when using the present apparatus, permits more uniform hardening of the photo-polymerizable material.

Since the lamp, due to the overload applied to it, is heated to a considerable extent, although only for a short time, a cooling device in the form of a fan, for example, switches on after half of the operating time has elapsed and stays switched on after the termination of the radiation for a period of approximately two to three times the operating time, and thus remains switched on at the end of the radiation.

Only subsequent to this period, when the cooling device has been switched off, can the lamp be ignited again so that destruction of the lamp by too rapidly succeeding overloads is prevented.

The source of rays with a lens for directing the radiation into the light conductor, which is preferably a liquid light conductor, and the cooling device with the electric switching are conveniently housed in a casing, which can be adapted to be inserted in a console. It is possible to eliminate the lens if the reflector surrounding the source of rays directs the rays into the light conductor. In order that no undesired formation of erythema or burns will occur due to unintentional irradiation of portions of tissue, the liquid light conductor has absorption means, which will absorb radiation below a wavelength of 320 nm, or radiation will be limited by an intermediate filter to a radiation above 320 nm. It is also possible to provide filters before or after the light conductor in order to absorb rays below 320 nm or, respectively, transform the same into the range exceeding 320 nm.

A holding grip may be arranged close to the outlet opening of the light conductor so that it may be easily handled and a releasing device can be mounted on the grip so that the radiation process can be triggered via a connection on the apparatus casing. The releasing device on the holding grip can be replaced by shaping the connection on the apparatus casing in the form of a circular push switch which, for example, may be actuated by the pressure of an elbow of the operating personnel. In addition, a delay switch can be provided in the electric circuit, by which the start of the radiation can be delayed to any desired extent. Another possibility of starting the arrangement is to coupled the connection on the apparatus with a pedal switch which is actuated by foot pressure.

Further, the present apparatus is simple to maintain, because only short time overloading of the lamp occurs and there is a period when no radiation is emitted due to the safety switching of the cooling device, so that unnecessary wear of the lamp is avoided. If, however, the lamp should not perform efficiently anymore, it can easily be removed from the apparatus and replaced by a new one. To this end, the lamp may be shaped as a plug-in unit together with the reflector surrounding it.

In order to enable the invention to be more readily understood, reference will now be made to the accompanying drawings, which illustrate diagrammatically and by way of example an embodiment thereof, and in which:—

Fig. 1 is a perspective schematic view of a radiation apparatus;

Fig. 2 is a graph of the electric power input per centimetre of arc length of the lamp in the apparatus of Fig. 1, as compared with a lamp arranged in a previously proposed apparatus operable according to the aforesaid pulse method, as a function of the radiation time in arbitrary units and

Fig. 3 is a graph of the hardness of photo-polymerizable dental layers or parts obtained by the apparatus of Fig. 1 as compared to the hardness obtained by the aforesaid previously provided apparatus with the same dose, as a function of the radiation time in arbitrary units.

Referring now to Fig. 1, there is shown a radiation apparatus 10 having an ultraviolet

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ray source 12 surrounded by a reflector 24, the ray source 12 and the reflector 24 representing a plug-in unit 26 shaped as a casing insert. The ray source 12 is either a high pressure mercury lamp or a lamp with additions of tin or iron compounds in order to increase the radiation intensity, especially in the long-wave ultraviolet range. A lens 18 is positioned in front of the ray source 12 for focussing the radiation from the reflector 24 and the radiation coming directly from the ray source into a light conductor 14 which is preferably liquid filled and contains absorption and transformation liquids, in order that only rays in the wavelength range of more than 320 nm. will reach the place of radiation. The radiation can also be directed to the light conductor 14 from the ray source 12 and the reflector 24 surrounding the same, without the use of a lens 18. The apparatus 10 has a casing 32 in which there is a cooling device 16, for example in the form of a fan, for cooling the lamp 12. A connection 22, which is shown as a circular push switch in Fig. 1, is located on a sidewall of the casing. On actuating the push switch and thereby the connection 22, the ray source 12 is put into operation. In the casing 32 there is also an additional electric switch (not shown) for switching on the cooling device 16 after half the operating time of the lamp 12 and to keep it in operation after the termination of the radiation until about two to three times the operating time of the lamp has elapsed. The apparatus 10 is only ready again for operation after termination of the cooling operation.

In addition, the connection 22 can be coupled with a time element (not shown), in order to delay the start of the apparatus 10 after actuation of the push switch for a desired length of time.

The connection 22, however, for starting the apparatus 10, can also be short-circuited with a pedal switch (not shown) or a switch to be actuated by means of a handle 30 located on a free end of the light conductor.

At the same time, the handle 30 enables the liquid light conductor 14 to be handled easily so as to let the radiation coming out of the light conductor 14 be directed exactly at any desired location. The adjacent free end 20 of the light conductor is in the form of a smooth terminal piece which is removable in order that it may be sterilized.

The liquid light conductor 14 can be replaced by a fibre-type light conductor, and in this case, filter devices are additionally provided between the lens 18 and the end of the light conductor in order to absorb undesired wavelengths.

Fig. 2 is a graph comprising the power input of the lamps per centimetre of arc length for the apparatus shown in Fig. 1 (broken line curve) and for apparatus operating according to the aforesaid pulse method in which the lamp is continuously operated at base load and takes up an increased power only during the treatment, the power inputs per centimetre of arc length of the respective lamps, being plotted against time and all other parameters of the lamps being equal. In the apparatus operating according to the pulse method as described for example in British Specification No. 896,356 or U.S. Specification No. 3,014,156, the lamp is continuously operated at a low permanent load and is intermittently operated at higher load by, for example, short circuiting a part of a resistance in series with the lamp. This operation of the lamp according to the pulse method is shown in Fig. 2 by the full line curve. As the lamp is continuously operated at a low permanent load in the pulse method, the increase of load will be produced substantially instantaneously to produce a square wave form pulse the value of which is limited by a current limiting resistor. However, the lamp in the present method is not operated at a low base load and is operated each time to give a saw tooth form pulse as shown by the broken line in Fig. 2. As shown by the broken line for the present apparatus, the power input at the start of the operating time is less than that of the apparatus operating on the pulse method but at the end of the radiation, it is considerably higher, the dosage of radiation being the area under the curve in each case.

It will thus be understood that, for any lamp, "standard operation" as the term is herein employed, means that, when the lamp is operated with a given constant load, the power input per centimetre of arc length plotted against time gives a straight line parallel to the time axis as shown in the full line curve of Figure 2 (neglecting the constant low base load). However, with the present apparatus, operation is such that when the lamp is switched on the power input per centimetre of arc length is less than that at the constant state of the lamp when on standard operation, but rises to a value which is considerably higher at the end of the operating time so that, all other parameters being equal, ~~the power input per centimetre of arc length plotted against time is a saw tooth wave form as shown in the broken line curve in Figure 2.~~ That is to say, as compared with standard operation, the lamp in the present apparatus is subjected for short periods to an overload such that at the end of the operating time the power input per centimetre of arc length is at least 4 times more than that of standard operation. The short starting time of the lamp being achieved as a result of the overload applied to it.

Fig. 3 is a graph showing the hardness of photo-polymerized dental layers as a func-

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tion of the radiation time for the compared arrangements.

It appears that after a certain operating time, i.e. radiation time, the hardness obtained with the present apparatus (broken line curve) will unexpectedly always be higher than that with the pulse apparatus, if the radiation doses are administered for equal times. It will thus be seen that, in order to attain the same hardnesses as with the present apparatus, longer radiation times will be required when using a pulse apparatus. In addition, it will be evident that the lamps in the present apparatus will have a longer life than those in a pulse apparatus, in which the lamps, in addition to their being operated continuously in base load, also require longer radiation times as compared with the present apparatus.

The different hardness may be explained by the fact that, when using the present apparatus, the hardening process takes place uniformly due to a continuous increase of the power input, whereas when using the pulse method, the outer layers will be hardened quickly so that these will obstruct the hardening of the inner layers.

WHAT WE CLAIM IS:—

1. Dental treatment apparatus for hardening photo-polymerizable dental treatment substances, wherein the apparatus comprises an ultraviolet ray source and a light conductor for transmitting radiation from the source to the place of treatment, and wherein means are provided for operating the source of ultraviolet rays so as to cause it to emit the dose of radiation required for hardening said substances from the time of switching-on for a period of 10 to 30 seconds, and said means and the source being so arranged that at the end of the radiation time the power input per centimetre of arc length of the ray source will be at least four times more than that of standard operation (as hereinbefore defined).

2. Apparatus as claimed in Claim 1, wherein a cooling device is provided and is arranged to cool the source of rays after half the operating time thereof has elapsed and for a period after termination of the radiation of more than two to three times the operating time, the arrangement being such that the ray source will only again be ready for operation at the termination of said period.

3. Apparatus as claimed in claim 2, wherein the apparatus comprises a casing within which are arranged the source of rays, a reflector adjacent the source, one end of the light conductor, and the cooling device.

4. Apparatus as claimed in claim 3, wherein a lens is provided for directing the radiation into the light conductor.

5. Apparatus as claimed in any one of the preceding claims, wherein the light conductor is a liquid light conductor.

6. Apparatus as claimed in Claim 5, wherein absorption and transformation media are provided in the liquid conductor for ensuring that the radiation leaving the liquid light conductor is in the wavelength range exceeding 320 nm.

7. Apparatus as claimed in Claim 5, wherein filters or transformation media for ensuring that the radiation leaving the liquid light conductor is in the wavelength range exceeding 320 nm are either connected before or after the light conductor.

8. Apparatus as claimed in any one of the preceding claims, wherein a removable and sterilizeable terminal piece is mounted on the free end of the light conductor.

9. Apparatus as claimed in Claim 8, wherein the terminal piece is smooth.

10. Apparatus as claimed in any one of the preceding claims, wherein a handle is provided on the free end of the light conductor.

11. Apparatus as claimed in claim 3 or any one of claims 4 to 10 when appended to claim 3, wherein the casing is provided with a connection for starting the apparatus.

12. Apparatus as claimed in claim 11, wherein the connection is shaped as a circular push switch.

13. Apparatus as claimed in claim 11, wherein the connection is coupled with a pedal switch.

14. Apparatus as claimed in claims 10 and 11, wherein the connection is coupled to the handle.

15. Apparatus as claimed in any one of the preceding claims, wherein the source of rays is combined with a reflector as a plug-in unit.

16. Apparatus as claimed in claim 15, wherein the plug-in unit is adapted to be inserted in a casing to be operated from the outside.

17. Dental treatment apparatus for hardening photo-polymerizable dental treatment substances substantially as hereinbefore described with reference to the accompanying drawings.

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Printed for Her Majesty's Stationery Office by The Tweeddale Press Ltd., Berwick-upon-Tweed, 1980. Published at the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

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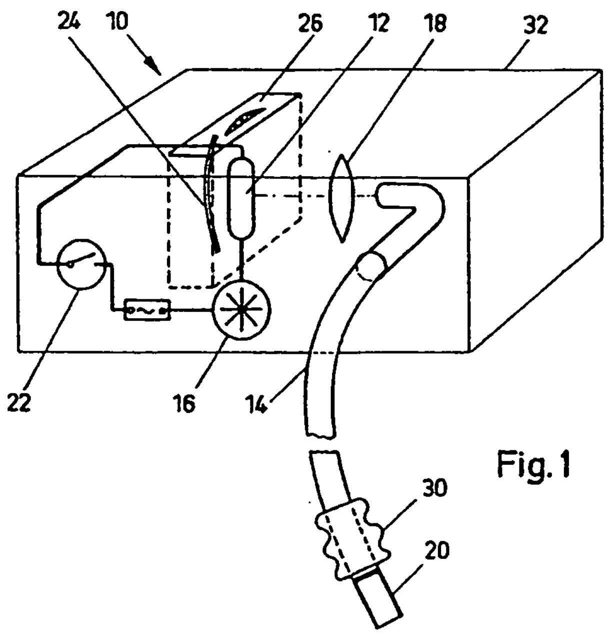

Fig. 1

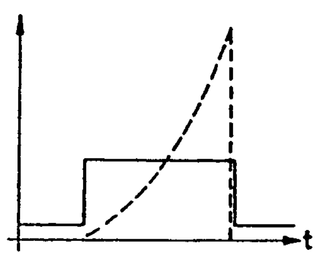

Fig. 2

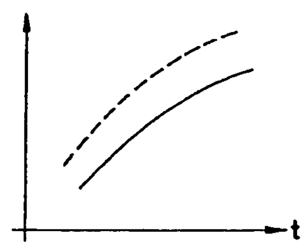

Fig. 3

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